R2800	Sub. Code
	521201

M.Sc. DEGREE EXAMINATION, APRIL – 2025.

Second Semester

Physics

QUANTUM MECHANICS – I

(CBCS – 2022 onwards)

Time : 3 Hours Maximum : 75 Marks

Part A $(10 \times 1 = 10)$

Answer **all** the following objective type questions by choosing the correct option.

1. $\left[x^2, \exp(x)\right]$ = ————————. (CO1, K5)

   (a) Zero (b) $4i[\ ]x$

   (c) $i[\ ]x$ (d) $2i[\ ]$

2. Which one of the function given below represent the eigen function of the momentum operator with the eigenvalue hk? (CO1, K4)

   (a) $\exp(-kx)$ (b) $\exp(+kx)$

   (c) $\exp(-ikx)$ (d) $\exp(+ikx)$

3. Consider infinite potential well with rigid walls are at $x = 0$ and $x = a$. What is the probability of finding the particle between $x = 0$ and $x = a$, if the particle is in second excited state? (CO2, K4)

   (a) 0 (b) 0.25

   (c) 0.5 (d) 1

4. The ground state energy of the three dimensional isotropic harmonic oscillator is (CO2, K3)

(a) $(1/2)\hbar\omega$ (b) $(3/2)\hbar\omega$

(c) $(5/2)\hbar\omega$ (d) $(7/2)\hbar\omega$

5. When inner product between two vectors vanishes, the state vectors are said to be (CO3, K4)

(a) Orthogonal to each other

(b) Normalized

(c) Linearly dependent

(d) They are zero vectors

6. The Hilbert Space dimension of the linear harmonic oscillator is (CO3, K4)

(a) One (b) Two

(c) Three (d) Infinity

7. The trial wavefunction chosen in the variational method must be (CO4, K4)

(a) Continuous and Single valued function

(b) Continuous and multi valued function

(c) Discontinuous and Single valued function

(d) Discontinuous and multi valued function

8. The following method is used for the approximate determination of the lowest or ground state energy level of a system when there is no closely related problem that is capable of exact solution. (CO4, K5)

(a) WKB approximation

(b) First order perturbation theory

(c) Variational method

(d) Born approximation

9. Which of the following process occurs even in the absence of perturbation? (CO5, K4)

(a) Induced Absorption

(b) Stimulated Emission

(c) Spontaneous emission

(d) Forbidden transition

10. In time dependent perturbation theory, one can calculate (CO5, K4)

(a) Transition probabilities among the eigenstates

(b) The shift in the energy eigenvalues and energy eigenfunctions

(c) The shift in the energy eigenfunctions alone

(d) The shift in the energy eigenvalues alone

Part B ($5 \times 5 = 25$)

Answer **all** questions not more than 500 words each.

11. (a) List the postulates of quantum mechanics and explain. (CO1, K2)

Or

(b) What are the admissibility conditions on wave function? Explain them with suitable examples. (CO1, K4)

12. (a) Write a note on alpha decay. (CO2, K2)

Or

(b) A particle of mass m is confined in one dimensional infinite potential well extending from $x = 0$ to $x = L$. The wave function of the particle is given as $\psi(x) = Ax(x - L)$. Find the normalization constant. (CO2, K5)

13. (a) In a three dimensional linear vector, check the completeness of the given basis. (CO3, K5)

$$|1> = \begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix},\ |2> = \begin{pmatrix} 0 \\ 1 \\ 0 \end{pmatrix} \text{ and } |3> = \begin{pmatrix} 0 \\ 0 \\ 1 \end{pmatrix}$$

Or

(b) Define Hilbert space. List the conditions for inner product. (CO3, K4)

14. (a) Describe Stark effect in hydrogen atom. (CO4, K2)

Or

(b) Write a short note on WKB approximation. (CO4, K3)

15. (a) Explain spontaneous transition. (CO5, K2)

Or

(b) When can we say a transition is forbidden? Elaborate with expressions for transition. (CO5, K5)

Part C (5 × 8 = 40)

Answer **all** questions not more than 1,000 words each.

16. (a) State and prove Ehrenfest's theorem. (CO1, K2)

Or

(b) Obtain the continuity equation for Schrodinger equation. Also explain the interpretation of wavefunction. (CO1, K3)

17. (a) Obtain the eigenfunctions of the one dimensional infinite deep potential well. (CO2, K2)

Or

(b) Solve the Hydrogen atom problem. (CO2, K2)

18. (a) Solve the one dimensional harmonic oscillator by constructing ladder operators. (CO3, K3)

Or

(b) Illustrate the features of the Schrodinger, Heisenberg and Interaction pictures and compare them. (CO3, K4)

19. (a) Obtain the expression for first order and second order corrections for the energy eigen values and energy eigen functions in the non degenerate time independent perturbation theory. (CO4, K3)

Or

(b) Derive the ground state wavefunction for the Helium atom using variational method. (CO4, K4)

20. (a) Derive Fermi golden rule for harmonic perturbation. (CO5, K4)

Or

(b) Derive the expression for the probability for stimulated emission in the time dependent perturbation theory. (CO5, K2)

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R2801

Sub. Code
521202

M.Sc. DEGREE EXAMINATION, APRIL – 2025.

Second Semester

Physics

MATHEMATICAL PHYSICS – II

(CBCS – 2022 onwards)

Time : 3 Hours Maximum : 75 Marks

Part A (10 × 1 = 10)

Answer **all** the following questions type questions by choosing the correct option.

1. The solution of the integral $\int_c |z| dz$, where c is the straight line from $z = -i$ to $z = i$ is (CO1, K4)
   (a) $-i$ (b) i
   (c) 1 (d) -1

2. If $f(z) = \frac{1}{(z-a)}$ and $\oint f(z) dz = 0$, then the closed contour c (CO1, K4)
   (a) Encloses a singularity
   (b) Does not enclose a singularity
   (c) $f(z)$ is analytic at all the points $z = a$
   (d) $f(z)$ is singular at all the points $z \neq a$

3. $\frac{\partial^2 u}{\partial t^2} - c^2 \frac{\partial^2 u}{\partial x^2} = 0$ is known as (CO1, K4)
   (a) heat equation (b) Laplace equation
   (c) wave equation (d) Helmholtz equation

4. Green function for Poisson's equation $\nabla^2\varphi = -4\pi\delta(r)$ is (CO1, K4)

(a) $\frac{1}{r}$ (b) $\frac{1}{r^2}$

(c) r^2 (d) r^{-2}

5. One of the recurrence relations for Bessel's function represents as (CO1, K4)

(a) $J_n = x(J_{n-1} - J_{n+1})$

(b) $2nJ_n = x(J_{n-1} + J_{n+1})$

(c) $nJ_n = x(J_n + J_{n-1})$

(d) $2nJ_n = x(J_{n-1} - J_{n+1})$

6. In Rodrigue's formula, $\int_{-1}^{+1} P_0(x)dx$ is equal to (CO1, K4)

(a) 0 (b) 1

(c) 2 (d) –2

7. Solution of $\int_0^x x^n J_{n-1}(x)dx$ is (CO1, K4)

(a) $x^n J_n(x)$ (b) $x^n J_{n-1}(x)$

(c) $J_{n-1}(x)$ (d) $x^{n-1} J_n(x)$

8. $J_0(x)$ and $J_1(x)$ are Bessel's functions, then $J_1'(x)$ (CO1, K4)

(a) $J_0(x)-\frac{1}{x}J_1(x)$ (b) $J_0(x)+\frac{1}{x}+J_1(x)$

(c) $\frac{1}{x^2}J_0(x)$ (d) $\frac{1}{x}J_1(x)$

9. Two groups are said to isomorphic if they have (CO1, K4)

(a) Same number of elements and same multiplication table

(b) Same multiplication table and different number of elements

(c) Same number of elements and different multiplication table

(d) Different multiplication table and different number of elements

10. A set of elements of a group, which itself forms a group is called (CO1, K4)

(a) Abelian group (b) Subgroup

(c) Same set of group (d) Cyclic group

Part B $(5 \times 5 = 25)$

Answer **all** questions not more than 500 words each.

11. (a) State and deduce the Cauchy's integral formula. (CO1, K3)

Or

(b) Write the expression of Taylor's theorem and expand $f(z)=\frac{1}{z}$ about $z=2$. (CO1, K4)

12. (a) Define Green function. Find the solution of the equation $\nabla^2\varphi = -\rho(r)$, using Green's function. (CO2, K2)

Or

(b) State and deduce the expression of Sturm-Liouville's theory. (CO2, K5)

13. (a) What are gamma and beta functions? Obtain the relation between beta and gamma function.

(CO3, K2)

Or

(b) Show that $nP_n = (2n-1)xP_{n-1} - (n-1)P_{n-1}$ form the recurrence relation of Legendre polynomial.

(CO3, K2)

14. (a) Deduce the expression of generating function of Hermite polynomials. (CO4, K5)

Or

(b) From the given equation $H_n(x) = (-1)^n e^{x^2} \frac{d^n}{dx^n}\left(e^{-x^2}\right)$, find the values for $n = 0,1,2$ (CO4, K4)

15. (a) (i) Explain the term cyclic group. (CO5, K3)

(ii) Generate a group from two elements A and B subject only to the relation.

Or

(b) Describe the concept of Isomorphism and Homomorphism. (CO5, K4)

Part C (5 × 8 = 40)

Answer **all** questions not more than 1,000 words each.

16. (a) State and prove the expression of Laurent's theorem. (CO1, K4)

Or

(b) (i) Discuss the singularity of $\frac{1}{1-e^z}$ at $z = 2\pi i$. (CO1, K3)

(ii) Find the sum of the residues of the function $f(z) = \frac{\sin z}{z\cos z}$ at its pole inside the circle $|z| = 2$. (CO1, K4)

17. (a) Explain Gram-Schmidt orthogonalization process of a set of linearly independent vector. (CO2, K4)

Or

(b) Obtain the solution of two dimensional heat how equation by the method of separation of variables. (CO2, K4)

18. (a) Obtain the equation of Rodrigue's formula for laguaerre polynomials. (CO3, K4)

Or

(b) (i) Show that $\Gamma\frac{1}{2} = \sqrt{\pi}$. (CO3, K4)

(ii) Show that $\Gamma n = 2\int_0^\infty e^{-t^2} t^{2n-1} dt$. (CO3, K4)

(iii) Show that $\Gamma(-1/2) = -2\sqrt{\pi}$. (CO3, K4)

19. (a) State and prove orthogonality of Hermite polynomials. (CO4, K5)

(Note: $\int_{-\infty}^{\infty} e^{-x^2} H_n(x) H_m(x) dx = 2^n n! \sqrt{\pi} \delta_{nm}$)

Or

(b) Obtain the equation of generating function for Laguene polynomial. (CO4, K5)

20. (a) State and prove the orthogonality theorem. (CO5, K6)

Or

(b) (i) What is representation group? Explain briefly. (CO5, K4)

(ii) Describe the reducible and irreducible representations. (CO5, K3)

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R2802

Sub. Code
521203

M.Sc. DEGREE EXAMINATION, APRIL – 2025

Second Semester

Physics

ELECTROMAGNETIC THEORY

(CBCS – 2022 onwards)

Time : 3 Hours Maximum : 75 Marks

Part A $(10 \times 1 = 10)$

Answer **all** the following objective questions by choosing the correct option.

1. An infinite plane carries a uniform surface charge. The electric field measured at a point which is at a distance r from the plane, (CO1, K2)

   (a) Inversely proportional to r

   (b) Directly proportional to r

   (c) Independent of r

   (d) Inversely proportional to r^2

2. The dielectric constant of a vacuum is (CO1, K1)

   (a) 1 (b) 0

   (c) $\in_0$ (d) undefined

3. Skin depth is defined as the distance after traveling in which the amplitude of the electric field vector reduces to times the original amplitude. (CO2, K1)

   (a) e (b) $1/e$

   (c) $1/e^2$ (d) $2e$

4. Electromagnetic waves carry _____. (CO2, K1)

(a) less charge (b) no charge

(c) more charge (d) infinite charge

5. The polarization angle i_p of the polarizer if the refractive index of the polarizer is 1.33. (CO3, K2)

(a) 53.06 (b) 0.236

(c) 0.232 (d) 0.997

6. Transverse Electric (TE) waves are (CO3, K1)

(a) s polarized (b) p polarised

(c) E polarised (d) B polarised

7. When EM wave passes through a gas, the electrons in the gas remain bound to the nucleus by (CO4, K1)

(a) Coulomb's force

(b) Linear restoring force

(c) Electromotive force

(d) Lorentz force

8. Scattered radiation is the dipole radiation that arises due to _____ of electrons. (CO4, K3)

(a) Periodic motion (b) Dispersion

(c) Emission (d) Repulsion

9. Number of plasma particles within the DeBye's shpere should be (CO5, K1)

(a) $>>1$ (b) $<<1$

(c) >1 (d) <1

10. The motion of a particle in a uniform electromagnetic field has a (CO5, K1)

(a) parabolic trajectory

(b) circular trajectory

(c) cycloid trajectory

(d) linear trajectory

Part B (5 × 5 = 25)

Answer **all** the questions not more than 500 words each.

11. (a) In the x-direction, there is a homogeneous electric field of size E = 50 N/C. Calculate the flux of this field across a plane square area with an edge of 5 cm in the y-z plane using the Gauss theorem. Assume that the normal is positive the positive x-axis. (CO1, K5)

Or

(b) Compare electrostatics and magnetostatics. (CO1, K2)

12. (a) Write down Maxwell's electromagnetic equations in differential and integral form. (CO2, K2)

Or

(b) How will you determine the types of polarization of an EM wave. (CO2, K2)

13. (a) Write down the general boundary conditions for electromagnetic waves. (CO3, K5)

Or

(b) If $n_1 > n_2$, show that the Brewster's angle is less than the critical angle. (CO3, K4)

14. (a) Distinguish between Normal and Anomalous dispersion. (CO4, K2)

Or

(b) Write about the different types of scattering of light. (CO4, K1)

15. (a) Write down the conditions for the existence of plasma. (CO5, K2)

Or

(b) What are the major elements of a Klystron? (CO5, K1)

Part C (5 × 8 = 40)

Answer **all** the questions not more than 1000 words each.

16. (a) Derive the electric field intensity due to a line charge. (CO1, K4)

Or

(b) Find B and H due to a circular current carrying loop. (CO1, K4)

17. (a) Obtain Maxwell's equations in integral and differential form. (CO2, K3)

Or

(b) What are standing waves? Write down the differences between standing waves and progressive waves. (CO2, K2)

18. (a) Derive Fresnel's equations. (CO3, K4)

Or

(b) Explain the reflection and refraction at dielectric interface for parallel polarization. (CO3, K4)

19. (a) Write down the characteristics and parameters of an Electromagnetic wave. (CO4, K2)

Or

(b) Explain electromagnetic dispersion theory. (CO4, K2)

20. (a) What is Pinch effect? Explain its types. (CO5, K3)

Or

(b) Explain the construction and working of a Magnetron. (CO5, K3)

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R2803	Sub. Code
	521505

M.Sc. DEGREE EXAMINATION, APRIL – 2025

Second Semester

Physics

Elective – MATERIALS AND CHARACTERIZATION

(CBCS – 2022 onwards)

Time : 3 Hours Maximum : 75 Marks

Section A (10 × 1 = 10)

Answer **all** the following objective questions by choosing the correct option.

1. Melt growth is the process of crystallization of (CO1, K1)
   (a) growth by high temperature
   (b) growth by fission process
   (c) fusion and resolidification of the pure material
   (d) obtaining high quality crystal

2. In _____ the solution loses particles, which are weakly bound to other components, and therefore the volume of the solution decreases (CO1, K1)
   (a) solvent evaporation method
   (b) hydro thermal growth
   (c) slow cooling method
   (d) gel growth

3. A material with one side is in one dimension and other two sides are larger is known as (CO2, K2)

(a) nanopowder (b) quantum well

(c) nano sheet (d) nanoparticles

4. The technique which uses to prepare nanostructured materials under top down approach is (CO2, K2)

(a) nanolithography (b) etching process

(c) sol-gel technique (d) photolithography

5. Chemical vapour deposition is used to obtain (CO3, K1)

(a) semiconductors

(b) non conducting polymers

(c) conducting compounds

(d) crystalline semiconductor

6. PVD is an atomistic deposition process in which there is a physical discharge of (CO3, K2)

(a) atoms or molecules

(b) high temperature

(c) vacuum atmosphere

(d) condensation process

7. The top of available electron energy level at low temperature is called (CO4, K1)

(a) Conduction band

(b) Energy gap

(c) Valancy band

(d) Fermi level

8. Conductive polymers are generally not (CO4, K2)

(a) Aromatic compounds

(b) Semiconducting material

(c) Thermoplastics

(d) Conjugated polymer chains

9. The disadvantage of liquid penetrant test is (CO5, K2)

(a) expensive

(b) slow

(c) depth restriction

(d) location defect

10. Ultrasonic waves can be a _____ and its frequency is about ———— (CO5, K1)

(a) longitudinal wave, 20 Hz - 20 kHz

(b) compressed wave, 20 Hz - 20 kHz

(c) longitudinal wave, more than 20 kHz

(d) compressed wave, more than 20 kHz

Section B ($5 \times 5 = 25$)

Answer **all** the questions not more than 500 words each.

11. (a) Explain the importance of Mier's T-C diagram. (CO1, K3)

Or

(b) Obtain the expression of super saturation, Also explain how to control it. (CO1, K3)

12. (a) Explain what aretop-down and bottom up approach. Give examples. (CO2, K4)

Or

(b) Describe the preparation of nanoparticles by polyoi method. Mention its merits. (CO2, K3)

13. (a) Explain the construction and working of physical vapour deposition method to prepare thin film. (CO3, K4)

Or

(b) Sketch the schematic diagram and discuss how to prepare thin film by spray pyrolysis method. (CO3, K5)

14. (a) Explain the role of polymer electrolytes in lithium batteries. (CO4, K3)

Or

(b) Discuss the structural factors responsible for high ionic conductivity. (CO4, K5)

15. (a) Explain the principle of pulse echo method. Mention its advantages and limitations. (CO5, K4)

Or

(b) Discuss the working of instrumentation of infrared detector. Mention its applications. (CO5, K3)

Section C (5 × 8 = 40)

Answer **all** the questions not more than 1000 words each.

16. (a) With the schematic diagram, describe how to grow a crystal by slow cooling method. (CO1, K4)

Or

(b) Describe the various types of gel. Mention its advantages and disadvantages of it. (CO1, K4)

17. (a) Discuss what are zero dimension, one dimension and two dimension nanostructured materials. Give examples to each. (CO2, K5)

Or

(b) (i) Describe the preparation of ZnO nanoparticles. (CO2, K3)

(ii) Differentiate quantum wire and quantum dots. (CO2, K3)

18. (a) With the neat diagram, explain the thin film preparation by chemical vapour deposition method. (CO3, K5)

Or

(b) Explain the reactive sputtering method to prepare thin film. (CO3, K4)

19. (a) Explain the theory of lithium transport in lithium batteries. (CO4, K4)

Or

(b) Describe the concept and feasibility of ion conducting polymer nanocomposites with examples. (CO4, K6)

20. (a) Explain the construction and working of acoustic emission technique. Mention its types and applications. (CO5, K4)

Or

(b) Discuss the principle, types advantages and limitations of liquid penetrant testing. (CO5, K5)

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R2804

Sub. Code
521401

M.Sc. DEGREE EXAMINATION, APRIL – 2025

Fourth Semester

Physics

CONDENSED MATTER PHYSICS — II

(CBCS – 2022 onwards)

Time : 3 Hours Maximum : 75 Marks

Part A (10 × 1 = 10)

Answer **all** the following objective questions by choosing the correct option.

1. Which of the following is the slowest polarisation method? (CO1, K1)
   (a) Ionic Polarization
   (b) Orientational Polarization
   (c) Electronic Polarization
   (d) Space charge Polarization

2. The dielectric strength of ferroelectric materials is mostly determined by the : (CO1, K2)
   (a) The material's hysteresis loop size
   (b) The presence of magnetic materials nearby
   (c) The strength of the electric field
   (d) the frequency of the applied voltage

3. What is the dielectric strength of mica? (CO2, K1)
   (a) 118 MV/m (b) 2000 MV/m
   (c) 200 MV/m (d) 1180 MV/m

4. The relative dielectric constant of polystyrene is 2.5. What is the polarization produced when 0.5 mm thick sheet of polystyrene's subjected to 220 V? (CO2, K4)

(a) 2.78×10^{-6} C/m (b) $3.91\ 10^{-6}$ C/m

(c) 4.12×10^{-6} C/m (d) 5.84×10^{-6} C/m

5. If a material is ferromagnetic, what shall be the value of X? (CO3, K3)

(a) Negative

(b) Small and positive

(c) Large and positive

(d) None of the above

6. Ferrimagnetic materials show spontaneous magnetization for (CO3, K2)

(a) All temperatures

(b) Temperatures below the Curie temperature

(c) Temperatures above the Curie temperature

(d) Only at absolute zero

7. The coherence length of the paired electron is (CO4, K1)

(a) 2.5 nm (b) 0.25 nm

(c) 0.01 nm (d) 0.001 nm

8. Cooper pair follows (CO4, K1)

(a) MB-statistics (b) BE-statistics

(c) FD-statistics (d) None of these

9. The vander-waals diameter of C_{60} is (CO5, K2)

(a) 1.0 nm (b) 1.1 nm

(c) 1.2 nm (d) 1.3 nm

10. Most promising applications of the CNT is _____. (CO5, K2)

(a) Paper batteries (b) Solar cells

(c) Space elevators (d) Stab proof

Part B (5 × 5 = 25)

Answer **all** the questions not more than 500 words each.

11. (a) Derive Clausius-Mosotti relation between polarizability and the dielectric constant of a solid. (CO1, K4)

Or

(b) The polarizability of the oxygen atom in air molecules is 9.7×10^{-41} C-m²/V. Calculate the average distance of the center of the negative charge cloud from the nucleus. (CO1, K3)

12. (a) Discuss the origin of ferroelectricity. What is polarization catastrophe? (CO2, K2)

Or

(b) Explain the applications of piezo - and ferroelectric materials. (CO2, K3)

13. (a) An atom with L = 2 and 0 spin angular momentum is placed in a uniform magnetic field of induction 2 Wb/m². Calculate the rate of precession of the resultant magnetic moment. Also, calculate the corresponding linear frequency and the radius of an electron in the ground state. (CO3, K3)

Or

(b) What is spontaneous magnetization? How does it vary with the temperature of the material? Explain the structure of ferrite. (CO3, K1)

14. (a) What are Type and Type II superconductors? Draw a distinction between them. (CO4, K1)

Or

(b) Write down the 1st and 2nd London equations. What do you mean by London penetration depth? (CO4, K3)

15. (a) Write a short note on : (CO5, K3)

(i) Carbon nanotubes and

(ii) Graphene.

Or

(b) Describe excitons in nano semiconductors. (CO5, K5)

Part C ($5 \times 8 = 40$)

Answer **all** the questions not more than 1000 words each.

16. (a) What are the various components of the local electric field at an atom in a crystal? Obtain the Lorentz relation for the local electric field. When is this relation valid? (CO1, K1)

Or

(b) Deduce an expression for the electronic polarizability of an atom on the basis of classical theory. (CO1, K4)

17. (a) What is Ferroelectricity? Derive an equation for the dipole theory of Ferroelectricity. (CO2, K1)

Or

(b) (i) Explain the origin of piezoelectricity,

(ii) 'All ferroelectric crystals are piezoelectric, but the converse is not true', Explain the reason.

(iii) Mention some important applications of piezoelectricity. (CO2, K3)

18. (a) (i) Describe the quantum theory of paramagnetism and explain how it removes the shortcomings of Langevin's theory.

(ii) Give an account of the domain theory of hysteresis. (CO3, K2)

Or

(b) Elucidate Neel's theory of antiferromagnetism and show how the ferromagnetic behavior of ferrite can be explained from Neel's theory. (CO3, K2)

19. (a) (i) Explain the formation of the Cooper pair in a superconductor.

(ii) Give an account of the BCS theory of superconductivity and discuss how it explains the superconductivity phenomenon? (CO4, K3)

Or

(b) (i) Discuss Josephson effect.

(ii) Give formulation of DC and AC Josephson effect.

(iii) Discuss how the AC Josephson effect can estimate. (CO4, K2)

20. (a) Explain in detail the synthetic strategies of nanomaterials with suitable examples. (CO5, K3)

Or

(b) Discuss the quantitative description of the density of states of nanostructures. (CO5, K5)

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R2805

Sub. Code
521402

M.Sc. DEGREE EXAMINATION, APRIL – 2025

Fourth Semester

Physics

NUCLEAR AND PARTICLE PHYSICS

(CBCS – 2022 onwards)

Time : 3 Hours Maximum : 75 Marks

Part A (10 × 1 = 10)

Answer **all** the following objective questions by choosing the correct option.

1. Heisenberg exchange forces arises due to _____ exchange. (CO1, K4)

   (a) No (b) Spin

   (c) Space (d) Space-Spin

2. Effective range theory is also known as shape independent theory. (CO1, K5)

   (a) True (b) False

   (c) Partially True (d) Partially False

3. Liquid drop model fails to explain _____. (CO2, K2)

   (a) Atomic mass (b) Binding energy

   (c) Alpha emission (d) Magic numbers

4. Deformed shell model refers to _____ model. (CO2, K4)

(a) Bohr (b) Rutherford

(c) Nilsson (d) Collective

5. Stripping reaction is the inverse of _____ reaction. (CO3, K3)

(a) Knock out (b) Pick-up

(c) Fission (d) Fusion

6. Which of the following is used as control rods in nuclear reactors? (CO3, K1)

(a) Boron (b) Beryllium

(c) Light water (d) Heavy water

7. In gamma decay, atomic and mass number changes. (CO4, K2)

(a) True (b) False

(c) Partially True (d) Partially False

8. In internal conversion, excited atom emits _____ energy electrons. (CO4, K4)

(a) Zero (b) Low

(c) High (d) All of them

9. _____ refers to the symmetry of a system under spatial inversion. (CO5, K2)

(a) Parity (b) Charge

(c) Spin (d) Iso-spin

10. Proton is made up of _____ quarks. (C05, K5)

(a) uuu (b) uud

(c) udd (d) ddd

Part B (5 × 5 = 25)

Answer **all** the questions not more than 500 words each.

11. (a) Justify the statement, "Nuclear forces are spin dependent". (CO1, K2)

Or

(b) Give a short note on Quadrupole moment. (CO1, K3)

12. (a) Sketch and explain mass parabola. (CO2, K3)

Or

(b) Comment on Magic numbers. (CO2, K5)

13. (a) Explain the source of stellar energy. (CO3, K1)

Or

(b) Derive Breit-wigner one level formula. (CO3, K4)

14. (a) Label the parity violation in beta decay. (CO4, K3)

Or

(b) Give a brief note on nuclear isomerism. (CO4, K4)

15. (a) Classify fundamental forces. (CO5, K2)

Or

(b) Explain Gell-Mann-Nishijima formula. (CO5, K3)

Part C (5 × 8 = 40)

Answer **all** the questions not more than 1000 words each.

16. (a) By describing concept of exchange particles, explain the origin of nuclear forces. (CO1, K5)

Or

(b) Describe the energy dependence of low energy scattering with effective range. (CO1, K3)

17. (a) Elucidate Weizsaecker semi-empirical formula. (CO2, K6)

Or

(b) Outline the significance of collective model of nucleus. (CO2, K4)

18. (a) Explain Bohr's idea of compound nucleus model. (CO3, K2)

Or

(b) State and explain Reciprocity theorem. (CO3, K4)

19. (a) Give a physical derivation for the transmission probability of alpha particle. (CO4, K6)

Or

(b) Elaborate Fermi's theory of beta emission. (CO4, K3)

20. (a) Outline quarks and Leptons, Baryons. (CO5, K4)

Or

(b) Discuss CPT invariance. (CO5, K2)

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R2806

Sub. Code
521403

M.Sc. DEGREE EXAMINATION, APRIL – 2025

Fourth Semester

Physics

THERMODYNAMICS AND STATISTICAL MECHANICS

(CBCS – 2022 onwards)

Time : 3 Hours Maximum : 75 Marks

Part A $(10 \times 1 = 10)$

Answer **all** the following objective type questions by choosing the correct option.

1. The phase-trajectory of a one-dimensional harmonic oscillator has the shape of (CO1, K2)

   (a) straight line (b) ellipse

   (c) circle (d) parabola

2. The number of quantum states $\Phi(\in)$, is related to the density of quantum states, $g(\in)$, by the relation (CO1, K3)

   (a) $g(\in) = \frac{\partial \Phi}{\partial \in}$

   (b) $\Phi(\in) = \frac{\partial(\in)}{v}$

   (c) $g(\in) = \frac{\Phi(\in)}{v}$

   (d) $\Phi(\in) = \frac{\partial g}{\partial \in}$

3. The probability of a microstate in a microcanonical ensemble is (CO2, K3)

(a) $\frac{e^{-\beta\epsilon_i}}{z}$ (b) $e^{-\beta\epsilon_i}$

(c) $\frac{1}{\Omega}$ (d) $\Omega e^{-\beta\epsilon_i}$

4. In a microcanonical ensemble at equilibrium, S is (CO2, K1)

(a) maximum (b) minimum

(c) constant (d) zero

5. The fluctuations in a parameter are measured by (CO3, K2)

(a) mean values

(b) mean square value

(c) mean square deviations

(d) none of these

6. In canonical ensemble, fluctuations occur in (CO3, K1)

(a) energy only

(b) concentration only

(c) energy and concentrations

(d) neither energy nor concentration

7. The probability of occupancy of the Fermi-level at a non-zero temperature is (CO4, K3)

(a) 100% (b) 50%

(c) 25% (d) 0%

8. The chemical potential of an ideal Bose gas is always (CO4, K2)

(a) negative (b) positive

(c) zero (d) negative or zero

9. Conversion of boiling water at 1 atmosphere and 100°C in vapour is (CO5, K2)

(a) zero order phase transition

(b) first order phase transition

(c) second order phase transition

(d) third order phase transition

10. Clausius-Clapeyron's equation holds for (CO5, K1)

(a) first order phase transition

(b) second order phase transition

(c) both (a) and (b)

(d) neither (a) nor (b)

Part B $(5 \times 5 = 25)$

Answer **all** questions not more than 500 words each.

11. (a) Ten distinguishable particles are to be placed in four energy levels with energies 0, $\in$, $2\in$ and $3\in$. If the total energy of the system consisting of these particles is $3\in$, find

(i) the number of possible macrostates of the system,

(ii) the number of microstates corresponding to each macrostate,

(iii) the total thermodynamic probability of the system. (CO1, K3)

Or

(b) Starting form Gibb's energy (G), show that

(i) $C_p = -T\dfrac{\partial^2 G}{\partial T^2}$ and

(ii) $H = -T^2\left[\dfrac{\partial}{\partial T}\left(\dfrac{G}{T}\right)\right]_p$. (CO1, K4)

12. (a) The microstates of a system in contact with a heat reservoir at temperature T can have the following energies $E_n = n\in,\ n = 0,1,2,\ldots.$ Obtain the partition function $z_N(T)$ of the system and hence evaluate its mean energy $E(T)$ and entropy $S(T)$. (CO2, K4)

Or

(b) For a system in grand canonical ensemble, a state with energy kT and 11 particles has a probability of 0.002, whereas a state with energy $2kT$ and 10 particles has a probability of 0.001 . Find the temperature of the system if it has a chemical potential of $-2.12\times10^{-21}J$. Also determine the value of the grand partition function (ln 2 = 0.693). (CO2, K5)

13. (a) Two indistinguishable boson and fermion particles have to be adjusted in a state whose degeneracy is three. How many ways the particles can be adjusted? (CO3, K2)

Or

(b) Show that the mean square fluctuations in the energy of a system in a canonical ensemble is proportional to the heat capacity of the system. (CO3, K4)

14. (a) Show that the zero-point pressure of a Fermi-gas is $P_o = \frac{2}{5} nE_F$ where n is the density of fermions and E_F their Fermi energy. (CO4, K3)

Or

(b) Find the probability of one-dimensional random walk. (CO4, K5)

15. (a) Calculate Einstein's frequency for copper for which $\theta_E = 230k$. Given $h = 6.6 \times 10^{-34} J - \sec$, $k = 1.37 \times 10^{-23} J/K$. Using the obtained result show that the classical theory result $C_v = 3R$ should be valid for copper if $T > 230°C$. (CO5, K5)

Or

(b) Give a general description of the variation of specific heat of a diatomic gas with temperature and outline the theoretical attempts to explain this quantitatively. (CO5, K3)

Part C $(5 \times 8 = 40)$

Answer **all** questions not more than 1000 words each.

16. (a) What do you mean by the density of states of a particle? Obtain its expression for an ideal gas in three-dimensional space. On what factors does it depend? (CO1, K1)

Or

(b) Using the various thermodynamic potentials for a gas with a fixed number of particles, prove the following identities:

(i) $\left(\frac{\partial T}{\partial P}\right)_H = \frac{T^2}{C_p}\left(\frac{\partial\left(\frac{U}{T}\right)}{\partial T}\right)_p$,

(ii) $\left(\frac{\partial E}{\partial V}\right)_T = T^2\left(\frac{\partial\,(PE)}{\partial T}\right)_V$,

(iii) $\left(\frac{\partial E}{\partial S}\right)_T = -P^2\left(\frac{\partial\left(\frac{T}{P}\right)}{\partial P}\right)_V$. (CO1, K1)

17. (a) Show that for an ideal classical gas in contact with a heat reservoir at temperature T, the entropy is given by $S(T,V,N) = NK\left[\ln\left(\frac{V}{N}\right)\left(\frac{2\pi mKT}{h^2}\right)^{\frac{3}{2}} + \frac{5}{2}\right]$. (CO2, K3)

Or

(b) Show that for an ideal gas in grand canonical ensemble,

(i) $N = \frac{1}{\beta}\left(\frac{\partial}{\partial\mu}\ln Z_N\right)_{T,V}$ and

(ii) $E = \frac{-\partial}{\partial\beta}(\ln Z_N)_{T,V} + \mu N$. (CO2, K4)

18. (a) Derive Bose-Einstein distribution law. (CO3, K3)

Or

(b) Show that the fluctuations in the energy of a system in contact with a heat reservoir are inversely proportional to $\sqrt{N}$, where N is the number of particles in the system. (CO3, K4)

19. (a) Apply Bose-Einstein statistics to photon gas and hence derive Planck's law for the spectral distribution of energy in black-body radiation. (CO4, K3)

Or

(b) What is Bose-Einstein Condensation? Obtain the expression for the temperature at which is starts. (CO4, K2)

20. (a) Derive Debye's formula for the specific heat of solids. Comment on the assumptions and achievements of the theory and compare it with Einstein's theory of specific heats. (CO5, K4)

Or

(b) What is Ising model? Show that one-dimensional Ising model does not explain the spontaneous magnetization. Discuss the reason for it. (CO5, K3)

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